VOL. XLIV NO. 2

TRANSACTIONS

OF THE

AMERICAN FISHERIES SOCIETY

MARCH, 1915

Published Quarterly by the American Fisheries Society
at The Aquarium, New York, N. Y.

Entered as second class matter, December 21, 1914, at the Post Office at New York, N. Y.,
under the Act of August 24, 1912.

TRANSACTIONS

of the

American Fisheries Society

//

"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

VOLUME XLIV, NUMBER 2

1914-1915

Edited by The Recording Secretary

MARCH, 1915

Published Quarterly by the Society

NEW YORK, N. Y.

CONTENTS

TAXONOMIC AND FISH-CULTURAL NOTES ON THE CHARS OR TROUTS OF NEW ENGLAND

By WILLIAM CONVERSE KENDALL,
Assistant, Bureau of Fisheries.

I have no formal paper to present, but should like to call your attention to a few matters pertaining to the chars or "trouts" of New England, which include the "brook trout" as their best known representative.

Authorities differ regarding their geographical distribution, and whether or not the different forms should be regarded as distinct species. They are mainly boreal and of wide distribution in the northern hemisphere, as a group extending entirely around the globe and northward to even beyond the limits of open water. There are southward extensions and more or less isolated occurrences as far as southern Europe and in the United States to New England and northern California. The brook trout, however, is found in the mountain sources of some rivers as far south as Georgia and Alabama.

The typical char of Europe is *Salvelinus alpinus,* which is nominally represented in Greenland by *Salvelinus stagnalis* and in the north Pacific by *Salvelinus malma.* There are intermediate nominal species, however, which are apparently so closely related that from descriptions and scanty material it is difficult to decide where one species leaves off and another begins. Some authorities regard all or most of them as constituting one species composed of various forms, each possessing characteristics of merely local significance.

The first two pictures shown you (demonstration) are of the common lake trout from a small lake in western Maine. In Maine, it is known as "togue" and in New Hampshire and Vermont as "lunge" or "longe," and farther west as "lake trout," "Mackinaw trout," etc.

The lake trout has been regarded as a distinct genus from the rest of the chars and for a long time bore the generic name of *Cristivomer*. This genus was apparently based upon the form of the vomer alone, but it has recently been shown that this ground is untenable. Therefore, according to the rules of taxonomy, this genus *Cristivomer* has to be abandoned and the fish again falls into the generic group designated as *Salvelinus*. However, while this character alone does not serve to generically distinguish it, there are indications that there may be found some other quite tangible characters, or even more than tangible—something that we can get hold of and grasp—that will separate it as a distinct genus, regardless of the character of the vomer. As a rule, we cannot find one character alone that can be regarded as of generic value. There must be a combination of characteristics and each of these may alone be of little significance or value but in combination wholly sufficient. In regard to the lake trout, one apparently minor characteristic is a permanently strongly forked tail, and another is its general deep water habitat. Other chars have forked tails in their younger stages and in some instances the character is retained in later life, but this is irregular and inconstant in those fishes while it is constant in the lake trout. The forked tail alone, however, will not avail, so it must be associated with other characters which investigation may quite probably reveal, for the fact that the younger stages of other *Salvelini* have forked tails and the lake trout a permanent one suggests that the lake trout originated earlier in the line of ascent or evolution than did the other chars from some common fork-tailed ancestry. If this is true the lake trout must naturally and necessarily be a distinct genus. However, the combination of distinctive characters must be demonstrated before the fish can be entitled to resume the title of *Cristivomer*.

In this connection, I beg to refer to another matter which bears upon this question but not directly upon the New England chars. Mr. C. Tate Regan, of the Brit-

ish Museum, has decided that the generic name *Oncorhynchus* which has been adopted for the Pacific salmon is no longer tenable because he found an individual of a Japanese species, which was supposed to be of the group formerly called *Oncorhynchus*, having as few anal rays as the genus *Salmo*. One of the distinguishing marks of the genus had been held to be the more numerous rays in the anal fin than in that of the genus *Salmo*. However, besides some minor associated or combined differential characters, the Pacific salmon have one prominent characteristic that sets them out as a sharply defined group of fishes, and which, taken in combination with predominant, if not defined, structural characters, I think should be regarded as sufficient to distinguish it as a genus. That characteristic is that the fishes composing this group invariably die soon after having reproduced once only in their life time.

Reverting to the New England trouts, the four pictures following the lake trout are of the blue-back trout (demonstration). For many years this fish was supposed to be peculiar to the Rangeley lake in western Maine, but was comparatively recently discovered in Rainbow lake, the headwaters of a tributary of the West Branch of the Penobscot river. The first published description of this species was by Girard in 1853, from which time no other species of the saibling group of chars was recognized in New England until about 1885, when the golden trout of Sunapee lake was discovered. A peculiarity of the blueback was that until comparatively recently they were small fish, never over 9 or 10 inches long and never varied from about one-fifth of a pound each. They were hardly ever taken on a hook but were netted by the inhabitants in large quantities as they ascended the affluents to spawn, appearing in those places about the tenth of October. Finally they began to decrease rapidly in number, so rapidly that the Maine Fish Commission considered it necessary to prohibit catching them by any means. The commissioners apparently ascribed the growing scarcity to excessive and untimely fishing. But such fishing

had been carried on for fifty, seventy-five or a hundred years with no apparent reduction in the number of the fish. Finally, however, they became so scarce that when I was up there in 1901 we had a man on those brooks night and day and failed to secure a single fish and none was seen in any of their former spawing places. We did manage to secure one fish, in Kennebago stream, weighing about three-quarters of a pound, which was much larger than usual. I got several others in 1903 and 1904, all large fish. Subsequently they appear to have become extinct. The few that remained prior to their disappearance increased in size. The cause of the extinction, I believe, was the "successful" introduction of the landlocked salmon, which, with the common trout, subsisted to a great extent upon the little blue-backs. The blue-backs disappeared down the maws of the salmon as it were. It was not until 1891 that other food was afforded them by the introduction of the smelt, which was too late.

The later phenomenal increase in size of the blue-back was probably attributable to the smelt, in the young of which it found an increased and unaccustomed abundant food supply, as the young smelt apparently go into deep water while almost in a larval state.

The pictures following those of the blue-back are of the famous golden trout, or *Salvelinus aureolus* of Sunapee lake (demonstration). It was not described until 1887. It is closely related to the blue-back, and it is difficult to distinguish the preserved dead specimens of this fish from blue-backs of the same size under the same conditions. In fact, it was believed by many to have appeared in Sunapee lake as the result of the introduction of blue-backs. Some, however, maintained that it was the introduced Europen saibling. Those who advocated the blue-back theory would have been delighted had they foreseen the increase in size of that fish in Rangeley lake, as the principal argument of the opponents of the theory was that the Rangeley blue-back was always a much smaller fish. Regarding this fish, I have

fears, which, however, are not shared in by many who are familiar with the conditions at Sunapee, that the beautiful golden trout, unless the object of the utmost conservative attention, is doomed to extinction in the same way and for a similar reason as the Rangeley blue-back.

After the pictures of the Sunapee trout you come to the "peculiar trout" of Monadnock lake or Dublin pond, New Hampshire, described and named by Mr. Samuel Garman, of the Museum of Comparative Zoology, Cambridge, in 1885. This fish (demonstration) was the subject of controversy for many years, to settle which specimens were sent, from time to time, to different authorities. It was sometime in the early sixties that Prof. Louis Agassiz, having received some specimens, considered them closely allied to a form found in Switzerland. Later, Prof. Baird pronounced it a variety of the common lake trout, after which, by others, it was denominated a color form of the common brook trout, and apparently, subsequently to his description of it as a new species, Garman regarded it as a color variety of the brook trout. To cut a long story short, I will simply state that the trout appears to be in its habits and general appearance more closely allied to the golden trout of Sunapee lake and the blue-back of Rangeley than to the common trout. All that it seems to have in common with the latter is the mottled dorsal and caudal fins.

The last picture (demonstration) is not a good representative of the brook trout as we know it, but in respect to its coloration there is an interesting fact. That fish was artificially raised in a little pond in Falmouth, Maine. You will notice that the colors of the ventral region are brilliant orange or yellow. The trout from which the eggs were obtained that produced the Falmouth fish were from a pond in Hollis, Maine. They were of an intense rose color, but in their progeny became the yellow trout of Falmouth, indicating that color of this kind alone can be of no specific value, at least so far as the brook trout are concerned.

There is another matter pertaining to these trout of more fish cultural importance than what I have previously said, which I wish to submit for your consideration. Some ninety years ago a distinguished anatomist and embryologist by the name of Rathke described the ovaries of various fishes and amongst these were the Salmonoid fishes, concerning which he mentions that while the Salmonoids have no oviduct and the ovaries are suspended free without any covering in the abdominal cavity, there extends back behind each ovary a narrow flat band which commonly arises at the upper and posterior end of the plate-like ovary, gradually diminishes in width backward, and finally becomes lost towards the end of the abdominal cavity. In the salmon proper, he states, it disappears upon the air bladder, opposite the commencement of the last fifth of the abdominal cavity, in the fresh water trout on the side of the intestine not far from the anus, and in the *Coregoni* on the intestine close to its end. In all these fishes, he says, the central abdominal cavity must take the place of an oviduct, as it receives the eggs when they are detached and allows them to make their exit by a single opening at its posterior extremity.

In the smelt, however, which is a salmonoid fish, he says that there passes from each ovary a band, one end of which is attached to the dorsal, the other to the abdominal wall, so that, in each lateral half of the abdominal cavity, there is a chamber which receives the eggs when they are detached from the ovary; that the two chambers ultimately unite above the anus; and in fact, close in front of the place where, in other fishes, the oviduct is situated.

In 1883, Huxley studied the smelt and reviewed Rathke's paper, confirming the statements Rathke made, but in the case of the smelt going a little farther. Huxley showed that in this fish there were oviducts formed in this way: Each ovary has the form of a half-oval plate, with the curved edge ventral and the straight edge dorsal. The latter is suspended by a narrow mesoarial fold of peritoneum from that part of the dorsal wall of

the abdominal cavity corresponding with the ventral surface of the air bladder. The ovary was stated to be covered on its inner surface by the peritoneum and that the outer face gives rise to a great number of ovigerous lamellae which are disposed transversely to the length of the organ and perpendicularly to its body. Before going further into this subject, it may be well to state that the folds or projections of the peritoneum, the lining of the visceral cavity, support and more or less attach to each other the organs within the cavity. It may be likened to a membranous sack with no opening which, placed in the abdominal cavity, forms a lining of two coats and by projecting folds invests, or partly invests, or is attached to some of the organs, forming their support. The fold which proceeds from the dorsal area of the cavity and supports the ovary is known as mesoarium or mesovarium. In the Salmonoid fishes then, according to the authorities named, this mesoarial fold covers the inner surface and extends around the lower edge and for about one-quarter or one-third of the height of the outer surface of the ovary, thus leaving the laminae on this outer side free or exposed without covering. However, in the case of the smelt, it was shown that the inner mesoarial covering continued, not in the narrowing band mentioned by Rathke in the other salmonoids or as a dorsoventral partition, but a short distance back of the posterior end of the ovary it folded over and became attached to the lateral abdominal wall, thus forming a funnel-shaped channel, the wide mouth of which was close behind the ovary and the small end joining with the corresponding one on the other side in a common outlet at the ovipore. The lower portion of this oviduct, therefore, accordding to this idea, was formed below by the extension of the peritoneal or mesoarial fold and above by the abdominal wall.

The idea that the eggs of these fish were deposited free in the abdominal cavity has been handed down from Rathke to the present day in all literature pertaining to salmonoid fishes. Do not understand that I am going to

try to controvert the statements of Rathke, Huxley, or any of the great masters, for I am not. But, as Rathke did not go quite so far as did Huxley in the case of the smelt, I venture to suggest that Huxley and others did not go quite far enough in respect to the other salmonoid fishes—at least that their application of the principle laid down to all salmonoid fishes was too general, and there may be exceptions similar to those shown by Huxley in the case of the smelt.

Some years ago, for purposes of classification, I was examining some chars in the National Museum and wished to ascertain the sex of the fish. Upon opening a Sunapee trout (*Salvelinus aureolus*) I was surprised to find extending from each ovary what appeared to be a tube exending nearly to the ovipore where it joined its fellow of the opposite side, making a common outlet channel. These were what are termed spent fish. I do not know whether they had been stripped or not, but there were full-sized eggs in each of these tubes. Until I found the second tube I thought it was an intestine. I also found that the ovary appeared to be completely covered with a membrane. Another specimen showed the same apparent conditions. I have not those fish here, but they are in the National Museum collection and, I have no doubt, can be seen. However, I have a fish of another kind.

This fish is the common brook trout, but there does not seem to be any tube extending for the whole distance from the ovary to the ovipore. Yet, if you will examine it, you will observe that each ovary is completely invested by a membrane with an opening at a shoort distance behind the posterior end of the ovary. The fish, however, is not ripe, but one that would have required perhaps three months for it to reach that stage. Therefore, it cannot be positively stated whether or not the whole ovary is pernanently completely covered. However, whether it is or not, or whether other kinds of salmonidae have their ovaries covered completely or not makes but little difference in regard to the points I wish to

make, although it would support my views and emphasize those particular points if they were shown to be so.

In respect to the salmon and trout in fish culture, it has been, consciously or unconsciously, assumed that Rathke, Huxley and other anatomists following them were correct and that as the eggs were deposited free in the abdominal cavity all that was necessary to do was to get them out and use them and that no harm would be done to the fish. The abdominal cavity was regarded as a sort of bag filled with eggs and in order to get them all that was necessary was to use pressure and the eggs would run out.

In stripping trout (*Salvelini*) it is well known that it is necessary to press several times to get all of the eggs, and it is customary for the stripper to try the fish to ascertain if the eggs will flow. He presses along the ventral surface from forward toward the tail and if he gets no eggs the fish is returned to the car or pen for it to ripen. When eggs are obtained by a light preliminary pressure, he repeats the pressing or stripping movement, a little harder each time, until all that can be expressed are forced out and the process usually, I may say almost invariably, results in some blood, fæcal matter and mucous coming with the last eggs, indicating that considerable force is used. If the eggs were all ripe, it should not be necessary to exert much force. When naturally depositing her eggs, the fish does not lose any blood, and they are extruded, so far as we know, in an easy flow. All of the ripe eggs are emitted but it takes time for the process as the eggs do not all ripen at the same time.

The point that I want to make is this: That when such undue force is used in stripping the fish, this very delicate membrane may be ruptured or the ovary injured, especially if the membrane completely covers the ovary as has been suggested.

I ought to mention that at the thirteenth annual meeting of this society, Mr. Charles G. Atkins presented some notes on the landlocked salmon, regarding which, among other things, he said: "Among the migratory salmon of

the Penobscot, ovarian disease is very rare; but with the land-locked salmon of the Schoodic lakes it is very common. In 1883, by careful observation, we learned that 18 per cent of the female fish were affected with some disease of the ovaries, resulting in defects of the eggs which were apparent to the eye, in some instancs involving the entire litter, but in general a very small number of eggs. The phenomenon was observed before artificial breeding began at Grand Lake stream, and does not appear to be influenced thereby."

We do not know how extensively that phenomenon had been observed prior to that fishery conference, because not a great deal of anatomical study or many observations had been made on the land-locked salmon, but this suggested to me that a rupture of the membrane or injury to the ovary had possibly caused the ovarian disease. I will mention further that I have seen a number of the golden trout of Sunapee lake with distorted and diseased ovaries, and hardened eggs in them. Taken together with what I saw in the National Museum fish, this fact and Mr. Atkin's statement gave me a suspicion that those abnormal ovaries after all were probably due to rough stripping. I have not had time for thoroughly investigating this subject, but hope that I or someone may soon settle the question.

Even the small amount of evidence already presented suggests that no harm and possibly much good can result from exercising more care in stripping the fish than has been employed in the number of instances that have come under my observation.

DISCUSSION

Mr. Titcomb, of Vermont: Dr. Kendall has very properly emphasized an important point for fish culturists, that we should use great caution in stripping to avoid injury to the membrane around the ovary. Another point to which I would call attention is, that if too much pressure is applied in expelling the eggs, the undeveloped eggs of the next season's series may be injured. One often hears the argument made that we should not catch trout before the breeding season, because to do so means the destruction of the eggs. But no matter when you catch trout, eggs will be taken because there is always a series developing. In May you will destroy just as many eggs as you will in September.

Mr. Neal, of Maine: The fish in my State are a conundrum. We have tried different methods and have made numerous mistakes. Perhaps if we had had more assistance from the scientists we should have had better success. It is still a question with us whether it is possible for us to stock our lakes permanently with land-locked salmon and trout. We have about 2,300 lakes and ponds in Maine, most of them adapted to these fishes, and they have been stocked. We have eleven hatcheries and hatch millions of trout and salmon, but in some localities we have been stocking lakes with salmon and trout for twenty years, and there has never been a trout caught there. George's lake, for example, has been stocked extensively for the past fifteen years, but there has never been a trout caught there, and only large salmon weighing over five pounds. As soon as the ice goes out there is good fishing, but only the salmon, and they run very large. At Swan lake, only fifteen miles from there, stocked in a similar manner, there is excellent fishing of both land-locked salmon and trout. Most of the salmon weigh from three to five pounds and very rarely as much as ten, while the trout weigh from a pound up and have been taken weighing eight pounds. We are trying in every way to solve these problems, which puzzle us, and will welcome any assistance the scientist can give us.

Mr. Graham: The question of introducing fishes into different waters is a very important one. As Dr. Kendall says, there is no doubt that the introduction of the land-locked salmon into the Rangely lakes caused the disappearance of the blue-backed trout. On the other hand the land-locked salmon were introduced into Sunapee lake, and while they thrived very well and were caught in large numbers as long as they kept planting them year after year, the deep-water trout also kept increasing, and I believe are increasing to-day. During the past four or five years the Sunapee trout have been caught by the thousands. But the smelts are very abundant in Sunapee lake, and apparently they have kept the salmon from destroying the trout. It seems to me, then, that any lake containing trout should be abundantly stocked with smelt before the salmon are introduced.

Along this line I wish to make a few remarks about the western salmon introduced from Oregon. These have been successfully established in Sunapee and New Found lakes in New Hampshire, by which I mean that they have been caught in large numbers, ranging in weight from a pound up to sixteen or seventeen pounds, but whether they will ever reproduce there we do not know. The Massachusetts Commission has had a little experience with these same salmon. Two years ago we planted in Lake Quinsigamond, in the city of Worcester, Mass., 10,000 young salmon from four to five inches in length, and last year 20,000 more. The lake had been carefully screened before stocking, and it is full of smelts. Here are some of the results: The fishermen caught this year in July, right in the city of Worcester, between 500 and 1,000 salmon, weighing from two and a half to five and a half pounds. Now, judging by these results, it seems to me good business to introduce these fish whether they will reproduce or not. This lake in Worcester abounds with pickerel, yellow and white perch, and other fish of that nature, yet we have introduced the western salmon, and in two years' time they have grown to as great a weight as five and three-quarter pounds.

Mr. Hayford, of New Jersey: Some of this discussion has had to do with the Rangely lakes. I had charge of the station at that place for five years and may be able to offer some suggestions concerning the disappearance of the blue-back trout from my own experience. There the brook trout spawn about the first of October and the blue-backs

about the tenth of October. Then some ten days later, October 20, the land-locked salmon go up the same streams and use the same spawning grounds, and therefore destroy a great many of the trout eggs. On account of the low temperature the eggs do not hatch until April, and before that time the lumbermen come down these streams with their logs and dynamite. Both these conditions no doubt have something to do with the disappearance of the trout.

ONE YEAR OF PROTECTION AT THE SANTA CATALINA FISH RESERVE

By CHARLES F. HOLDER, L.L. D.,
Throop College of Technology, Pasadena, Calif.

It may be of interest to the American Fisheries Society to learn the attempts to protect the island of Santa Catalina, California, a recognized spawning ground, from the market fishermen. The writer has been in touch with the conditions at the islands off the coast of Southern California for about thirty years, and has had every opportunity to observe the effect of over-fishing as applied to the great marine fishes of the Southwest.

Twenty-five or thirty years ago, before the introduction of the gasoline launch, the waters about Santa Catalina abounded in a most remarkable variety of large game and food fishes, among which were the yellowtail, barracuda, albacore, white sea bass, black sea bass, two species of swordfish, the whitefish, many kinds of rock bass, and many more too numerous to mention. In 1885-6, when the writer first saw the island, nearly all these fishes could be caught in large numbers, the supply being apparently inexhaustible. So many were caught at this time by anglers that the writer organized a little society, raising a fund to send the fish to Los Angeles where they could be given to the poor and to various institutions. In fact, there were so many that people would not trouble themselves to carry them away, and on or about the year 1890, it was not an unusual sight to see literally tons of food fishes thrown into the bay to feed the sea lions and sharks. Such a supply of fine game fishes, as they ranged up to one hundred pounds in weight, soon attracted the attention of anglers from all over the world, and in the year 1898 the writer caught a large leaping tuna with a rod and reel. Soon after this the Tuna Club was organized by the writer to prevent the over-slaughter and over-catching of these fine game fishes, the work be-

ing accomplished by inducing the public to fish with a very fine line instead of the big hand-lines which they had formerly used, a procedure that made it impossible to land a fish of sixty pounds weight within half an hour; previous to this these large fishes having been hauled in with a hand-line in a very few minutes. In this way the Tuna Club produced a remarkable change. Distinguished anglers all over the country joined it and a great object lesson was given in fair play and conservation; as a result, the over-catching and waste was absolutely stopped.

Very soon another element, menacing to the fishes, came into the field. This was the introduction of the gasoline launch. This enabled hordes of alien fishermen —Greeks, Italians, Chinese and Japanese—to reach the island, across the Santa Catalina Channel, in an hour or two, haul their nets and return in a very short time. It did not take many years for the effect of this to be apparent, and conservationists in Los Angeles County, interested in sea fishing, took up the matter and began to interest themselves in methods to regulate the catch. Every attempt was made to induce the fishermen to observe some care during the spawning season of fishes, and a special attempt was made to protect the spawning sardines in Avalon bay.

It was soon found that it was like "talking up the wind," as these men were out for fish and they proposed to take all they could get on every trip, and if the market was so over-loaded that there was danger of the price being lowered, boatloads of the finest kinds of market fish were thrown into the ocean and fed to the sharks. Conservationists finding that they could not argue with these men, sought the aid of the state legislature and the county authorities, but here politics entered into the situation and it was evident that the market fishermen's vote was a decided factor in the situation. Various attempts were made to secure laws and legislation, but for one reason or another, they all failed until 1913. During all these years the Tuna Club had led in these fights for the

conservation of the fishes and bore the brunt of the burden, which meant various attacks.

In 1913 the writer made a careful examination of the situation, summed up the information from eminent authorities, and decided that the fishes of Southern California had decreased, since 1886, 75% or 80%, and that it was emminently necessary that something should be done. The claim which I made, which was based upon my own observations and examination of the island by Dr. David Starr Jordan and many other experts, was that Santa Catalina and San Clemente islands were spawning grounds for the great sea fishes of Southern California; in other words, were sources of supply for market fishes of all the region about, and I beg herewith to include a letter received from Dr. David Starr Jordan bearing on this point:

DECEMBER 5, 1912.

DR. CHARLES F. HOLDER,
Throop College of Technology,
Pasadena, Cal.

DEAR SIR: I trust that you may be successful in having Santa Catalina and San Clemente islands set aside as game preserves. These two islands and the smooth waters off their shores are the spawning grounds, above all others, of the greatest game fish in the country. The white sea bass, the great jewfish, the spearfish, swordfish, tuna, bonito, albacore, the Japanese tuna (yellow-fin tuna), all spawn on the rocky and other places about these islands, as well as a multitude of smaller fishes valuable to the angler or to the markets.

Many of these fish spawn in the kelp which surrounds these islands. The netting carried on inshore disturbs these fishes at spawning time, and it is said that there has been a very marked falling off of these species. As Avalon, on Santa Catalina, is the great center of big game fishing, the disappearance of any of these species makes a great loss to the people who have investments there as well as to the visitors who come there for fishing purposes.

It is desired to prohibit the use of seines and all nets for market purposes within three miles of the shores of either of these islands. This allows the professional fisherman the entire Santa Barbara channel, Santa Rosa, San Miguel, and the rest comprising the Santa Barbara group.

I trust that you and our friends will be successful in getting the statute passed which shall protect these islands and set them apart as spawning grounds for the great game fishes of southern California.

Very truly yours,
DAVID STARR JORDAN.

It was argued that the fish would spawn along the shores of these islands in the summer months and that

the young would return to these regions the following year, and when large enough, would swim out into the channel and become the legitimate market fishes of the country. The peculiar methods of the market men of Southern California were absolutely fatal to the carrying out of a hypothesis of this kind, as they would follow up schools of fishes, surround them with great purse-nets, during the day time, taking from five to ten tons at a haul, of spawning sardines, or the larger fish; as this was carried on every day and every hour in the day, whenever the fish could be found, it was absolutely fatal to any method of protection. Not only this, every night the Japanese fishermen would come in flocks to the island and set their nets, generally in the form of gill-nets or seines, fastening them to the shore or kelp, and run them out from one hundred to a thousand feet into the ocean. A report made to the writer from San Clemente Island showed that there were fifty of these set-nets set in less than a mile and a half on the east shore of this island in one night. Besides this, there were other methods of taking the fish.

This was kept up day and night, in season and out, for about fifteen years, and the end soon came to some of the largest and most valuable of the fishes. Among these I would mention the leaping tuna. Fifteen years ago this fish was found in such vast numbers, within three miles of Santa Catalina Island, that it became a valuable and important source of income to hundreds of people and bid fair to become one of the great economic fishes of the State of California, and as valuable as the great tunny fisheries which have been carried on in the Mediterranean sea from the earliest historical times. The leaping tuna in California had a peculiar habit of coming inshore to feed at night or late in the afternoon, and I believe they spawned within the five-mile limit at Santa Catalina. In any event, these miles and miles of nets extending out into the ocean into their natural feeding ground where they pursued the flying fish, stopped them, just as innumerable hurdles would stop any animal, and had such

an effect upon them that they were absolutely driven away and for the last ten years there were less tunas caught than in a single month ten or fifteen years ago. In fact, the leaping tuna industry, attracting thousands of dollars to the Pacific coast in the form of anglers from all over the world, was absolutely ruined, and during the present season of 1914, the first leaping tuna of over one hundred pounds has been seen in years and but one caught.

Such was the situation in 1913, when I determined to literally take the question to the country and if possible induce the legislators to do something. I made a report giving full particulars of the situation at Santa Catalina Island showing the deadly decrease of the fisheries and its relation to sport, the market man, and the State in general. This was read to a Fish Protective Association which had been formed as a sort of an organization through which to work on the legislature. Finally, with the assistance of many interested men, our bill was introduced, calling for the protection of the fisheries of Santa Catalina Island, on the grounds that it was, in the opinion of Dr. David Starr Jordan and many other experts, the spawning ground, and asking that region within three miles off shore should be called a spawning ground and that all net fishing should be prohibited within that region. It was specifically allowed in the bill, that any one could fish with a hand-line. This was done because at that time the Japanese were catching all their albacore, which are canned as tuna, in this way. There was, by any stretch of the imagination, no class legislation in this, as everybody was served exactly alike; even the men whose fishing depended on netting for bait were prohibited. In a word, all netting was stopped within three miles of the shore, yet all the market fishermen and all the anglers could fish within this region with either the hand-line or rod and reel. This bill, then, did not interfere with the men who caught albacore and canned them, now one of the most important industries on the coast, nor did it interfere with the angler, who was said

to bring a million dollars to Southern California every year. The only persons it interfered with were those directly aimed at—the market fishermen of Los Angeles, who had hundreds of square miles of coast on which to haul their nets, but who insisted upon despoiling the shore line of this island which was known and demonstrated to be the source of supply of their own business. This bill was carried through both houses of the legislature despite the protests of 3,000 market fishermen and their friends of San Pedro, and other coast towns, and became a law in August, 1913, the result of twenty-five years of almost constant endeavor.

To those who had been working in this field of conservation, it was a moment of keen gratification, and did I have the time it would give me pleasure to mention the names of the scores of distinguished men in America who aided in this most important fight, among whom I may mention Dr. Henry van Dyke, Dr. David Starr Jordan, Mr. J. B. Burnham, president of the American Propagation Society, Col. Theodore Roosevelt, Dr. George F. Kunz, of Tiffany & Company, and many more throughout the East. This was in 1913. In the summer of 1914, for the first time in fifteen years, large numbers of tuna were seen, and even in the fall of 1913, only a few months after the passage of this law, more yellow-fin tunas were seen in close proximity to the island than had been seen within the past decade. I took the pains to interview twenty-five or thirty of the professional boatmen at Avalon, Santa Catalina Island, men who had constantly fished the island from ten to thirty years, and it was their unanimous opinion that so many large fishes had not been seen on the spawing beds of Santa Catalina Island since the old days of 1890. In fact, a seeming miracle had been performed even in one season, and at the end of the season of 1914, it is the belief of all those who are most familiar with the situation, that if this spawning ground could be relieved from the incessant netting of the past twenty-five years, for at least five years, it could be restored to its normal condition.

The average citizen might think that a measure of this kind, advocated by all the great experts of the country, would not be attacked. Again, it was so evidently a movement in the interests of the marketmen themselves, that it might be imagined that they would be sufficiently intelligent to appreciate it, but I was not one to indulge in such a Utopian dream. They acted immediately and began to devise means to render the law ineffective. I venture to say there has not been a week since the passage of the bill that efforts have not been made to break the law, and it has been necessary for the friends of conservation to have the men arrested and see that their nets were destroyed, all of which was very much against the desires of conservationists.

In the spring of 1914 a society was organized in San Francisco whose object was to enable the markets of San Francisco and California in general, to place game on sale. That this might be accomplished with dignity and without creating any suspicion, it was given the euphonious title of "The People's Fish and Game Protective Association of California." I am reminded in this connection, of the statement of an old friend and missionary in San Francisco many years ago, when we were discussing the "ways that are dark and tricks that are vain" of the heathen Chinese. He told me that to enable them to purchase slaves and bring Chinese women into the country and to sell them at high prices in San Francisco, and to protect their criminals caught in carrying out their nefarious projects, it was necessary for them to have various organizations through which to work, and here are some of the names which he gave me and which were named by the most notorious highbinders in the San Francisco region. Note, if you please, the high-sounding names under which these desperadoes carried on their affairs:

"The Chamber of Far-Reaching Virtue, or the Kwong Tack Tong"; another the "Ping King Tong, or the Hall of Maintained Justice"; still another conveying the idea of lofty sentiments, was the "Po Shin She, or the Guild

for the Protection of Virtue," and what could be finer than the "Kai Shin She, or The Guild of Hereditary Virtue?"

What relation there could be between these high-sounding names and the People's Fish and Game Protective Association, will be apparent when I tell you that the founders of this society, claiming to be carried on in the interest of the conservation and the protection of the fishes of the State of California, were either marketmen, market-hunters, or commission-men engaged in the sale of wild game, or in some way identified with this business which means extermination to the wild life of the State of California. I am informed by President Newbert, of the California Fish and Game Commission, that it has been his painful duty to arrest some of them a number of times and that all are regarded with suspicion by those who are deeply interested in the non-sale of game.

This society proceeded at once to accumulate a large membership and to raise a large sum of money among those particularly interested in it in San Francisco—hotel men, restaurant keepers, etc. They became so brazen in view of their successes, that they decided to entirely rewrite the game laws of California and arrange them to suit themselves, notwithstanding the fact that everyone knew that their work meant the extermination of many of the wild animals of California. They invoked the referendum which had for its object the placing of wild ducks on sale in the markets, and to this they secured, it is said, 33,000 signers, an amazing body blow to the conceit of the conservationists of California, as it was not supposed that 33,000 persons so absolutely ignorant could be found in the state which prides itself upon its culture and higher education. Encouraged by their success in this direction these game bandits proceeded to invoke the initiative, demanding that all wild game in California be placed on sale in the markets. By this time the people of California were thoroughly awakened to the danger and in various ways, principally by publicity, they succeeded in July, 1914, in making the market-men

and members of this society, surrender. They failed in their petition by ten thousand votes. This leaves the Californians to vote on the referendum on the 3rd of November; there is still the danger that it may be carried and that as a result an army of market hunters will arise and the wild ducks will be a thing of the past on the Pacific coast.[1]

To illustrate the devastating nature of their brigandage in making their political deals to accomplish their end, the agents of this so-called Protective Association, when they reached the Port of Los Angeles, promised to put in their initiative a clause whereby the Santa Catalina Fish Reserve law would be revoked. I merely mention this to show that these men, all of whom were business men of San Francisco, would not hesitate to strike down the interests of another set of men or utterly repudiate the opinions of the National Government and the various experts who have expressed their views on the subject. I will, however, state that the secretary of this institution, when I explained the situation to him, gave me his word that he would remove it from the bill, which he did later on, and then came the defeat of the entire petition owing to the fact mainly, that the Hotel Men's Association of Southern California repudiated it and stood with us.

I have mentioned this as it seems to me it may be of interest to the distinguished members of this society in illustrating the point that there is a vital need in this country of public education, on the subject of the economic value of the fisheries. I mean by this that the masses of the people are absolutely ignorant of the great fundamental questions relating to this subject and that only this can explain the fact that an association of this kind could have secured 33,000 signatures to a petition

---

[1] They won by 8,000 votes, but we carried southern California by a large vote—58,000.—C. F. H.

NOTE: In 1914 the Santa Catalina Fish Reservation was again thrown open to netters on the ground of class legislation, and the work is being done all over again in the legislature of 1915, with the possibility of defeat by the combinations of the fish market men of Los Angeles and San Francisco.—C.F.H.

which the experts of the Department of Agriculture said meant extermination of the animals referred to by the petition. I have been so impressed with this that during the present season I have organized, with the co-operation of many distinguished men and women throughout the country, a society which we have called the "Wild Life Protective League of America," one of whose objects is to see that lectures are given in the public schools on the economic value of the fishes and the necessity of game laws, that the great game and food fishes of the country may receive adequate protection.

That I may not seem to be devoting this diatribe entirely to California, I beg to call your attention to the serious condition which holds in the Chesapeake bay where I am informed by Mr. Linthicum, a distinguished advocate of protection from Maryland, that the great and valuable shad fisheries of that region are practically doomed to extinction and that, despite the protest of the United States Fich Commission and the officials of the various adjoining states, these fishermen persisted in hauling their nets to the very limit of destruction. The enormity of this particular situation may be realized when it is known that the men were told that if they would permit ten per cent of the shad to pass up the river, its normal condition would be preserved. The absolute danger of the situation may be appreciated when it is understood that one day's haul by these men fifteen years ago produced more fish than the entire haul of the seasons of 1913 and 1914. In a word, the mendacious ignorance of the net-haulers is so extraordinary that it is evidently the duty of every citizen to take the matter in his own hands and encourage the Government to take charge of the great fisheries of the country and see that they are properly cared for and protected. Practically little is known of the fisheries of the Pacific coast, but it is well known that they are disappearing very much faster than they should, and by the time Los Angeles has one million inhabitants, the price of seafood will have become so high that it will place fish beyond the reach of the poor man

who has a right to include it among the cheapest of food supplies.

To return to the thought that suggested this paper, if one year's protection of the island of Santa Catalina can produce such interesting results, it is very evident that all authorities should be invoked to give all our waterways adequate protection.

EFFECTS OF CERTAIN METALLIC SALTS UPON FISHES

By ADRIAN THOMAS,
Clark University, Worcester, Mass.

Contribution from the United States Fisheries Biological Station, Woods Hole, Mass.[1]

It is not the purpose of this paper to give details, but simply to show certain general results which have been obtained during the course of investigation.

In the experiments upon which this paper is based, the small shore minnow or killie-fish (*Fundulus heteroclitus*) was used. This is a hardy fish and is plentiful in the waters of the Woods Hole district. Because of the abundance and hardiness of Funduli, they are well suited to experimental work. The fact that these fish are killed by certain salts is almost sufficient evidence that any other, more delicate, species would also be destroyed by them, only more rapidly.

Salts containing nearly all of the heavy metals have been used in the course of these experiments, but only a few will be dealt with in this article.

Conditions during experimentation were kept as nearly normal as possible in the laboratory. From five to ten fish were placed in battery jars of about two gallons capacity filled with sea water, to which was added sufficient of the salts to give the desired concentration. A constant stream of air was passed into the solutions, sufficient to supply the amount of oxygen needed, but not enough to super-saturate the media and cause the fish to succumb to "air sickness." The solutions were changed at least every forty-eight hours to insure freedom from products of metabolism, but experiments have shown that the fish would live in a healthy condition even if the water was changed only once a week, provided that no toxic substances were present.

---

[1] Published by permission of the Commissioner of Fisheries.

The temperature of the solutions ranged from about sixty-eight to seventy-four degrees Fahrenheit, which was not greatly different from the temperature of the water in the harbor. Records show the water there to range from about sixty-four to seventy-four degrees, during the period of the experiments.

The fish were fed during the experiments just before the solutions were changed, and sea mussels were used as food.

Experiments performed using copper sulphate showed that the fish absorbed the copper. While still in a healthy condition, the fish were taken from the solutions containing the copper, thoroughly washed, and water run through the alimentary tract to insure the removal of all copper not absorbed into the tissue of the fish.

After having been in a solution containing thirty parts to the million for forty-eight hours, it was found that the fish had absorbed .00079 per cent of their wet weight, or .0035 per cent of their dried weight.[1] The copper was determined by drying the fish to constant weight after washing, and then analyses for the copper made on the dried sample. About fifty copper determinations were made upon fish from varying concentrations of copper sulphate, and it was found that the fish would absorb the copper proportionally to the concentration of the solution, and also to the time exposed.

Copper chloride was used as well as the sulphate in some of the experiments, but it appears that not as much copper was absorbed in a given time from solutions of copper chloride, as from solutions of copper sulphate containing the same amount of copper. The sulphate also is apparently much less toxic than the chloride. In solutions of the sulphate, thirty parts to the million, it was impossible to keep the fish for much longer than ninety-six hours, but in solutions of the chloride of the same concentration the fish succumbed in a much shorter period.

---

[1]For detailed results see *Jour. Biol. Chem.*, Vol X, No. 4, May, 1912.

The question arises: Do these fish retain or eliminate the copper after a time? This may be partially answered by the following:

One hundred fish were placed in copper chloride solution containing thirty parts to the million, for two hours. At the end of this time twelve were taken for immediate analysis. The remainder were placed in running sea water, and after fourteen days ten more were taken for analysis. After twenty-five days had elapsed another sample of ten were taken for analysis. The three analyses agreed very closely, and seemed to show that even though removed from the source of pollution the copper content of the fish did not diminish.

During the experiment twenty-one fish died in the running water, the most of them (seventeen) during the first four days. The copper seems to have an accumulative effect.

Nickel chloride, ferric-ammonium-citrate, and potassium-di-chromate were also used, and analyses of the fish made after having been in various concentrations of these salts in sea water for different periods of time. None of these salts appeared to be toxic to the fish, however, and they could survive in concentrations of about two hundred parts per million for a week or two. This concentration was about the maximum used, and the time the longest that the experiments were run. Analyses showed that the fish had absorbed the metals nevertheless. That they were non-toxic may have been due to the fact that the salts in sea water were antagonistic to those employed. This is sometimes the case, as Loeb has shown.

Among other salts used in sea water and found to be non-toxic, were cobalt chloride, manganese chloride and zinc sulphate, but mecuric chloride, cadmium nitrate and sodium arsenate were found to be highly toxic. Analyses of the fish exposed to these salts, just mentioned, have not been made as yet so it is impossible to draw further conclusions.

An interesting point was found when a land-locked pond was discovered to contain a large number of this same species, *Fundulus heteroclitus*. The pond was located on one of the islands near Woods Hole, and so situated that it was possible for a very high tide to wash into it during a storm. Information that this happened every two or three years, was obtained from Mr. Vinal Edwards. It is highly probable that the Funduli were carried into the pond in this manner, and gradually accustomed to the fresh water. The water from this pond was fresh enough to be nearly drinkable and showed a density of only 1.0008. The Funduli taken from this source lived well in fresh water (hydrant water).

Although of the same species, these fish were more delicate than those taken from salt water, which might be expected; as they had less of the elements to resist than if they had been in the open waters, where they would be tossed about by the waves, and exposed to the rougher conditions there found. The scales of these fish were thinner and of a softer texture than those of the fish taken from salt water, and the fish were somewhat smaller than the average size of those used in the before described experiments, which only seemed to indicate that they were younger.

As might be expected the salts were much more toxic to these fish in fresh water than to the same species in salt water. This tends to the confimation of the belief that the salts in sea water were antagonistic in the experiments in which it was the basic media used.

Lead nitrate proved to be fatal within twelve hours at a concentration of three parts per million; aluminium sulphate, which is often used in the process of removing suspended matter from drinking water, was fatal within thirty-six hours at a concentration of fourteen parts per million, and in five days at a concentration of seven parts. It was impossible to use these salts in sea water on account of the insoluble precipitates which were at once formed. Zinc sulphate was fatal within forty-eight hours at a concentration of ten parts per million, but was non-

toxic in sea water. Copper sulphate was fatal within ten hours at a concentration of four parts; cadmium nitrate within thirty-six hours at six parts, while nickle and cobalt chloride were fatal within five days when as much as sixteen parts were used, and manganese chloride in six days at twelve parts per million.

It is needless to say that in these experiments duplicates have been run which closely agree, and that control experiments have also been made to eliminate doubt as to the effect of confinement in the jars in which the expriments were performed. The controls showed that the fish would live almost indefinitely under the conditions to which they were subjected, provided that none of the toxic salts were added.

We see that many substances are toxic to salt-water fish and many others to fresh-water fish. These contaminations may find their way into small streams and fish ponds, also fish may be subjected to them during transportation if the containers have these metals in their composition, for many kinds of waters have a great solvent action upon them. Further work is being carried on along these lines in which the effect of lime, coal-tar products, and factory wastes is being studied, and it is hoped that sufficient work will be completed in the near future to show the necessity of protecting our fish from these pollutions, to which many are now subjected.

A DESCRIPTION OF THE YOUNG STAGES OF THE WINTER FLOUNDER

(*Pseudopleuronectes americanus Walbaum*)

By W. E. SULLIVAN,
Assistant Professor of Anatomy, Marquette University, School of Medicine, Milwaukee, Wis.

The winter flounder (*Pseudopleuronectes americanus* Walbaum) is of interest for two reasons: First it is typical of the group of flat-fishes or flounders in its metamorphosis; second, it is a fish of great commercial importance. The flounders, as is well known, undergo a peculiar metamorphosis. The young, so far as has been ascertained, are symmetrical and swim upright; the adults on the contrary show a lack of symmetry, most marked in the position of the eyes and in the distribution of the pigment, and swim on their sides. These facts at once make the flounders of interest, and have made them objects of observation for half a century or more. Their commercial importance has resulted in the perfection of methods for their artificial rearing, and this insures a ready and abundant supply of material.

Review of Literature. This has been abbreviated as much as possible and incorporated in the text. There are some papers, however, that require special mention.

Agassiz's papers are the first works of importance on *P. americanus.* There are two things that have led me to believe that in the second paper Agassiz was not dealing with the winter flounder. The size of the fish at metamorphosis, as given by Agassiz, is much greater than I found to be the case and there are many inexplicable discrepancies in the plates.

In the text we find "The young flounder has already attained a considerable size before any signs appear of the change of the position of the eye on the left side; * * * and before the young fish shows the least tendency to

favor one side over the other. Not until the young fish is fully three-eighths of an inch in length can the first slight difference be perceived in the position of the two eyes (when seen from above), the left eye being somewhat in advance of the other." In all the fishes that I have examined the metamorphosis is practically completed before the fish has reached this size. The measurements given by Wiliams correspond to my own, and I think they may be taken as typical for this species.

Williams found a fish that metamorphosed at 14 mm. and tentatively called it *Limanda ferruginea* Storer. This may have been the species that Agassiz was studying. I have not examined the young of this species and Williams was not sure of his identification, and this is simply given as a suggestion as to the species Agassiz was working with.

When we turn to the plates we find that there is not only a difference in the size of the species but also that the time relations between the eye migration and the development of the tail are different from the conditions in *P. americanus*. In the species figured here the tail development is relatively much more rapid. It is probable that the development of the tail as described by Agassiz (1) is for another fish. It would seem that the same error would be made in both cases. The value of the work as far as it relates to the development of the tail is not impaired but it is probably the tail of a fish other than *P. americanus*.

Material and Apparatus. The sources of my material were the Rhode Island Hatchery at Wickford and the United States Hatchery at Woods Hole. The material collected at Wickford is referred to as Lot 1 and Lot 2. Lot 1 consists of fry that were hatched from eggs stripped from the female and fertilized March 26. In this lot there was also a small number hatched from eggs fertilized April 7. The difference in the time of fertilization will account for the differences in the rate of growth for this lot. The fishes in lot 2 are from females that were allowed to spawn and the eggs fertilized by males kept in

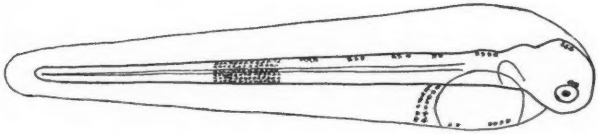

FIG. 1

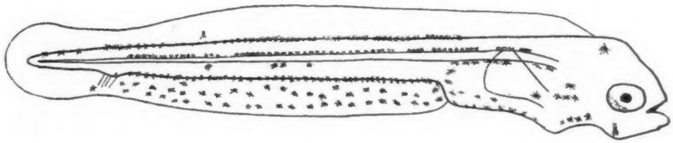

FIG. 2

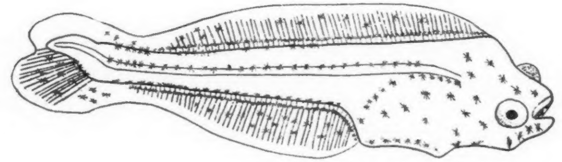

FIG. 3

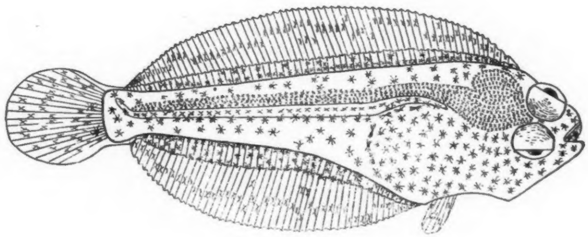

FIG. 4

EXPLANATION OF FIGURES

Figure 1. P. americanus at hatching (3.5 x 0.525 mm.).
Figure 2. P. americanus at twelve days (5.0 x 0.724 mm.).
Figure 3. P. americanus at six weeks (5.8 x 1.33 mm.).
Figure 4. P. americanus at eight weeks (6.5 x 2.75 mm.).

the same car. The extruded eggs were observed for the first time on April 15. The first of the fry appeared April 22.

The conditions under which the fry were hatched and reared approached very nearly natural conditions. The apparatus and the principles involved have been fully described by Dr. A. D. Mead in his papers on lobster rearing. The larger lots were hatched and reared in the rearing boxes in which the screens over the windows were replaced by sand filters. This was made necessary by the minuteness of the fry.

In rearing small groups for close observation a slightly different type of apparatus was used. The young were hatched and kept in cheese-cloth cylinders. The cylinders were about two feet deep and one foot in diameter. These were either fastened to the sides of the rearing boxes or allowed to float free. The rearing box in either case simply served as a breakwater. These cylinders were first designed by Mr. Barnes of the Wickford Hatchery. No difficulty was experienced in keeping small numbers in shallow dishes in the laboratory. The dishes were in all cases covered to keep out the dust and the water was changed every second day.

At Woods Hole the fry were taken directly from the rearing jars and kept in shallow dishes in the laboratory or in cheese-cloth cylinders in the harbor. In the latter case storage cars were used as breakwaters.

In describing the young of the winter flounder, four stages may be chosen that will show all the diagnostic characteristics for the purposes of identification from the time of hatching to the end of the second month. Stage 1 is the young fish at hatching and the description for this stage would apply equally well to the earlier stages in general. Stage 2 shows a fish of twelve days. It differs from Stage 1 in that the yolk is completely absorbed, the fin rays are beginning to appear and the pigment has a much wider distribution. Stage 3 is a fish of about 40 days and can be taken as representative of all fishes in which the eyes have reached the position shown in

Figure 3. Stage 4 is two months old and shows the condition at the end of metamorphosis.

Stage 1 (Figure 1). The length of the fish at hatching is 3.5 mm.; the greatest depth is 0.525. It is so translucent as to become almost transparent when placed in a glass dish. Only the pigment spots and the eyes are in evidence. It can be studied most effectively at this time by placing it against a white opaque background, that is, by the use of a white-enameled dish. The group of dark pigment spots shown on the posterior half of the body is characteristic for this fish. The only other patch of pigment of appreciable size lies over the rectum just posterior to the yolk. As in most young fishes at this stage the notochord, the digestive tract, the heart, the brain and the auditory vesicle can be clearly seen. The notochord is present as a straight tube. The dorsal, anal and caudal fins are represented by an unbroken finfold.

For several days after the hatching the external appearance of the fish remains the same. The changes that one observes first are the absorption of the yolk, the increase in pigmentation and the modification of the finfold. The even curves so conspicuous in the young stages become replaced by angles and the appearance of the fish is altered in consequence. The absorption of the yolk is very gradual and the period involved varies with the water temperature. At Woods Hole, where the average temperature was 39.5 degrees Fahrenheit, it extended from twelve to fourteen days. At Wickford with the higher temperature the period was shortened perceptibly, never extending over eight or nine days. The other processes of development showed much the same relationship to the water temperature, that is, in general the development is much more rapid at the higher temperature.

Stage 2 (Figure 2). The fish represented by Figure 2 is twelve days old. By this time it has reached a length of 5 mm. The yolk is completely absorbed and the young fish has come to depend entirely upon plankton for its food. The boundaries of the finfold correspond very closely to the boundaries of the fins of the adult, although

as yet the caudal fin is not differentiated. There is a slight thickening on the postero-ventral surface at a point where the first of the fin rays are to appear. The notochord is still straight and the eyes are still symmetrical. The pigmentation as shown in the figure is quite different from that at the time of hatching. The patch shown at the angle of the lower jaw is very characteristic, as are the four large pigment spots just ventral to the heart. There is a line of pigment along the dorsal side of the notochord and corresponding lines along the dorsal and ventral borders of the body. The spots along the ventral border are much more expanded than those forming the other lines. The patches on the abdominal region and over the heart are not as constant as the others mentioned. The dorsal finfold is either unpigmented or has a few scattering spots with no constant arrangement. In the ventral finfold the pigment is conspicuous and fairly regular. Here the spots form two lines that are practically unbroken. All the pigment so far described is black or brown as seen with transmitted light. Mingled with the black pigment of the ventral finfold are a number of small red asters of irregular distribution.

Between the second and third stages what we may call the more critical changes take place. The external changes are the migration of the eyes, the development of the fin rays, and the differentiation of the caudal fin. Accompanying the differentiation of the caudal fin is the upward bending of the notochord. The migration of the eyes is usually referred to as a very rapid change, consuming only a few days at the most. While it is only a question of interpretation as to what should be included in that period, I would favor including at least all those stages between the end of the second week and the end of the eighth week. Properly I think it should include the period extending from the time of fertilization to the completion of the metamorphosis. To refer to it as occupying only a few days is entirely misleading if not erroneous.

Stage 3. (Figure 3.) The type represented in Figure 3 averages 5.8 mm. in length. The fish from which the drawing was made was six weeks old, but, due to the variation in the rate of growth and development, there are found between the ages of five and seven weeks many fishes that have reached this stage. The features most in evidence at this time are the change in the position of the eyes, the well-developed fin rays, and the upward bend in the posterior part of the notochord. The left eye has reached at this time what may be described as a median dorsal position. About half of it can be seen from the right side. The right eye has taken a position slightly ventral to its former position. The upward bend in the posterior part of the notochord is very marked at this time. This bending of the notochord seldom begins before the end of the fifth week in living specimens. It has been pictured in younger stages, but I think this is due to the fact that the drawings were made from preserved material and that living specimens were not used for comparison. Unless great care is taken in the killing and fixing there is a distinct tendency for the posterior part of the fish to bend upwards. This is also true of fishes dying in dishes or rearing cars. Knowing that the notochord does eventually bend upward one might be led to interpret the upward bending of the posterior part of the fish as the upward bending of the notochord or at least indicative of it. The caudal fin rays are now well developed and the original finfold is notched just dorsal to the last caudal ray. The diphycercal fin of the early stages has now reached the heterocercal type. The part ventral to the notch is to become the caudal fin of the mature fish. Otherwise the outer line of the finfold is still unbroken and the fins are not entirely differentiated. The pigment distribution is shown in the figure.

From this time on the changes simply accentuate the processes already under way. After the sixth week the pigment on the left side tends to diminish in intensity.

Stage 4. (Figure 4). The fish here represented is about eight weeks old. At this stage the young fishes

have an average length of 6.5 mm. and an average depth of 2.75 mm. Most of the characteristics of the adult are present. The eyes, as shown in the figure, have taken the adult position; both are now functional on the right side. The caudal fin is practically separated from the dorsal and ventral fins but in most cases a slight remnant of the old finfold can still be observed. The fin rays of the dorsal and ventral fins are sufficiently developed to give a broken margin to the fins. The pigment is much more diffuse than in the earlier stages. The brain and spinal cord are now distinctly outlined superficially by the pigment spots over them. The fish is at this time very similar to the adult except for the asymmetry of the mouth. The mouth at this stage is symmetrical and in fact remains so for a considerable period. Only a slight degree of asymmetry can be seen in a fish of several centimeters.

In the later stages there is a gradual loss of pigment on the left side and a gradual increase of pigment on the right side. In a fish 8 mm. long the upper or dextral side is completely pigmented while the left side has lost its pigment with the exception of a few scattered spots, about twenty in number, in the region of the snout. At what time these spots are lost I do not know. They are entirely absent in a fish of 20 mm. and are probably lost considerably earlier.

Behavior of the young fish. There has been much speculation as to the cause of the turning of the flatfishes and the relation of the migration of the eye to the question of turning. In regard to this I can only say that I learned nothing in my study of the fishes through the period of metamorphosis that threw any light on the question. The study of the segmentation of the egg in other genera has added nothing. I think it would be interesting and possibly enlightening if the chemicals that produce the Cyclopean eye in the "normal-eyed" fishes were applied to the flat-fishes. I am convinced that the migration of the eye is but an external manifestation of the turning and is in no way the cause of the turning.

Observations on the young fish at rest strengthen this belief.

The fry are not strong swimmers, using "strong" to convey the idea that they maintain themselves in motion for long periods. It has often been remarked by those handling the fry in the MacDonald jars that the fish are found not only near the surface but throughout the entire depth of the dish, due to the fact that their swimming is spasmodic. Observation shows that the young fishes will suddenly cease swimming and sink to the bottom of the dish. After a short rest they will swim toward the surface again. We may use a typical case from a series of observations to illustrate this point. A fish of eight days was kept under observation for a period of ten minutes. During that period it stopped swimming twenty-three times. Five times it came to rest on the bottom of the dish; the other times it resumed swimming before reaching the bottom. After the observation the fish was kept in continuous motion for thirty minutes and at the end of the period showed no signs of fatigue. The intermittent swimming is characteristic of the fry and is not due to fatigue.

In the younger fishes, those under ten days, preference is shown to neither side when they come to rest. Extended observations on a large number of fry, taken either as individuals or in groups, showed that in a given number of times they would come to rest on the right side fully as often as they did on the left. This statement refers only to the cases where a large number were observed for a long period, a period of not less than an hour, or where an individual was kept under observation for a longer time. My first impression, gathered from casual observation in isolated cases, was that the fry favored the left side during this earlier period. After the tenth or twelfth day there is a tendency to favor the left side, and a fish of two weeks will come to rest on that side seventy-five times out of one hundred. Even after the eye migration has proceeded for some time the fish will occasionally come to rest on the right side. All of this, however, I

regard as simply a number of interesting observations that throw little if any light on the question of turning.

The young fry are strongly phototropic, and we should expect to find, and do find, the greatest number near the top and sides of the dish. Occasionally, when the source of light is such that a ray will run from the top to the bottom of the dish, the young fry cluster around this ray in the form of an inverted cone.

Escape from the egg capsule. For a day or more before hatching the young fish has the power of movement within the capsule. The movement is brought about by a series of contractions comparable to a peristalsis. The contractions are most marked in the posterior part and tend to push the fish forward. Through this movement the rupture of the capsule is brought about. The plane of rupture as observed in a number of cases is at right angles to the long axis of the body. The posterior half of the capsule then comes to lie on the back of the fish, dorsal to the head and body proper. The added weight dorsally turns the fish on its side, and in this position it struggles until freed from the capsule. This is usually accomplished in a period extending not over ten minutes.

Food of the young fry. Until the yolk is absorbed the young do not seek other nutriment. Indeed, for several days after the absorption of the yolk was completed no food was found in the gut of the fishes examined. The absorption of the yolk after hatching is entirely through the vascular system. At what time the direct connection between the gut and the yolk is lost I am not able to say. There is no trace of a connection at hatching. That the young do not depend on outside food until after the yolk is completely used up is further substantiated by the fact that they may be kept in the MacDonald jars used at the Woods Hole Hatchery for a period of two weeks, or the period during which the fry are nourished by the yolk. Beyond that time it is not possible to keep them. As is well known, the mechanism of the apparatus and the size of the jars are such as to prevent the admission of food material in sufficient quantities to maintain life. The diffi-

culty referred to above is undoubtedly one of feeding. In the fishes up to three weeks the only food found in the gut is made up of diatoms. A little later the smaller crustacea are found, and in the fishes that have completed metamorphosis Isopoda were invariably present. That in some cases at least the older fry eat the young is made plain by the fact that those in stage 3 were seen eating the younger fry.

RATE OF GROWTH

Measurements for Lot 1

The length and greatest depth are given in millimeters. Both Lot 1 and Lot 2 were fixed in Zenker's fluid and preserved in alcohol. The measurements are for preserved specimens:

May 4.	May 11	May 18	May 25	June 5
4.3 x 0.50	4.7 x 1.25	5.4 x 1.46	5.0 x 1.66	5.0 x 1.75
5.0 x 0.63	5.0 x 1.25	5.5 x 1.25	5.0 x 1.90	5.5 x 1.90
5.0 x 0.75	5.2 x 1.00	5.5 x 1.60	5.3 x 2.00	5.5 x 2.10
5.2 x 0.80	5.2 x 1.66	5.6 x 1.33	5.4 x 1.70	6.1 x 2.00
5.3 x 0.75	5.5 x 0.80	5.8 x 1.50	5.7 x 1.75	6.1 x 2.10
5.5 x 0.75	5.5 x 1.70	5.8 x 1.66	5.7 x 1.85	6.2 x 2.10
5.5 x 0.83	5.6 x 1.66	5.9 x 1.48	5.8 x 1.66	6.2 x 2.10
5.6 x 0.88	5.7 x 1.75	6.0 x 1.25	6.0 x 2.00	6.4 x 2.10
6.0 x 1.10	5.8 x 1.41	6.0 x 1.33	6.4 x 2.12	6.5 x 2.33
6.1 x 1.20	6.3 x 2.53	6.0 x 2.10	6.5 x 2.20	7.0 x 2.40

Measurements for Lot 2

May 3	May 4	May 5	May 6	May 7
4.3 x 0.60	4.3 x 0.63	4.5 x 0.63	4.8 x 0.50	4.3 x 0.66
4.3 x 0.60	4.4 x 0.64	4.7 x 0.60	4.8 x 0.60	4.5 x 0.50
4.4 x 0.60	4.6 x 0.65	4.7 x 0.60	4.9 x 0.66	4.5 x 0.63
4.4 x 0.66	4.7 x 0.63	4.9 x 0.62	5.0 x 0.60	4.8 x 0.60
4.5 x 0.54	4.8 x 0.57	4.9 x 0.62	5.0 x 0.63	5.0 x 0.64
4.5 x 0.63	4.9 x 0.60	5.0 x 0.60	5.0 x 0.66	5.0 x 0.69
4.5 x 0.64	4.9 x 0.63	5.0 x 0.60	5.0 x 0.68	5.2 x 0.70
4.8 x 0.60	5.0 x 0.63	5.0 x 0.66	5.0 x 0.74	5.2 x 0.75
4.8 x 0.60	5.0 x 0.68	5.1 x 0.68	5.2 x 0.68	5.3 x 0.75
4.9 x 0.66	5.2 x 0.66	5.7 x 0.75	5.3 x 0.68	5.6 x 0.90

May 8	May 9	May 10	May 11	May 12
4.5 x 0.63	4.8 x 0.66	4.5 x 0.60	4.6 x 0.80	4.5 x 0.69
5.0 x 0.69	4.9 x 0.60	5.0 x 0.72	4.7 x 0.68	4.9 x 0.75
5.0 x 0.78	5.1 x 0.70	5.0 x 0.75	4.9 x 0.84	4.9 x 0.80
5.1 x 0.66	5.3 x 0.75	5.0 x 0.78	5.0 x 0.75	5.0 x 0.87
5.3 x 0.76	5.3 x 0.90	5.1 x 0.70	5.0 x 0.81	5.0 x 1.00
5.5 x 0.85	5.5 x 0.72	5.2 x 0.87	5.0 x 0.85	5.0 x 1.10
5.5 x 0.85	5.5 x 0.90	5.4 x 0.97	5.0 x 0.86	5.1 x 1.10
5.5 x 0.90	5.8 x 1.00	5.4 x 1.10	5.0 x 0.90	5.2 x 1.00
5.6 x 1.00	5.9 x 1.00	5.1 x 0.90	5.1 x 0.90	5.2 x 1.30
6.0 x 1.10	6.0 x 1.20	5.1 x 0.92	5.1 x 0.92	5.6 x 1.20

May 14	May 15	May 29	June 5
4.5 x 0.60	4.8 x 0.70	4.7 x 1.10	4.5 x 1.20
4.6 x 0.63	4.8 x 0.75	4.8 x 0.83	4.5 x 1.25
5.0 x 0.60	5.0 x 0.84	5.0 x 1.10	4.6 x 1.60
5.0 x 1.00	5.0 x 0.85	5.0 x 1.10	5.0 x 1.00
5.2 x 0.66	5.1 x 0.91	5.0 x 1.20	5.0 x 1.12
5.2 x 0.83	5.1 x 1.00	5.1 x 1.50	5.0 x 1.33
5.5 x 0.75	5.1 x 1.00	5.1 x 1.50	5.0 x 1.33
5.5 x 0.80	5.1 x 1.10	5.2 x 0.98	5.3 x 1.43
5.6 x 1.10	5.3 x 1.00	5.2 x 1.50	5.5 x 1.50
5.8 x 1.10	5.6 x 1.34	5.2 x 1.52	6.0 x 2.17

BIBLIOGRAPHY

1. Agassiz, A.
On the Young Stages of Some Osseous Fishes.
I. The Development of the Tail.
Proc. Amer. Acad. Arts and Sci., Vol. V, p. 117.

2. Agassiz, A.
On the Young Stages of Bony Fishes.
I. ii. Development of the Flounders.
Proc. Amer. Acad. Arts and Sci., Vol. IV, p. 1.

3. Cole, F. J., and Johnstone, J.
Pleuronectes.
L.M.B.C. Memoirs, VIII, 1901.

4. Mead, A. D.
A Method of Fish Culture and of Transporting Live Fishes.
Thirty-ninth Annual Report of Commissioners of Inland Fisheries of Rhode Island.

5. Williams, S. R.
Changes Accompanying the Migration of the Eye and Observations on the Tractus Opticus and Tectum Opticum in Pseudopleuronectes Americanus.
Bull. Mus. Comp. Zool., Vol. XL, No. 1.

PRELIMINARY INVESTIGATIONS FOR THE SYSTEMATIC STOCKING OF STATE WATERS

BY DAVID L. BELDING,
Biologist, Massachusetts Department of Fisheries and Game.

Introduction.—This paper considers one phase of fish propagation, that broad subject which forms the ultimate aim of the activities of the American Fisheries Society. Its purpose is to sound a note of warning, not necessarily of alarm, to persons who are satisfied with the present conditions and methods of fish propagation, by pointing out certain important facts which have been overlooked in the past, but which are essential for the best development of our inland waters.

Although its nature renders the subject of general interest, the facts are presented solely from the standpoint of the State Fish Commission. The paper deals with the selection of suitable grounds for stocking, and the text of its message to each state is "know thyself." Unless a state fish commission has a thorough knowledge of its waters, the environment in which the fry and fingerling fish are to be placed, promiscuous stocking will eventually lead to considerable loss. Extensive hatchery production increases rather than decreases this error. A systematic method of stocking, based upon an accurate knowledge of the waters to be stocked and a satisfactory method of distribution are essential for the success of a state commission, and form the basis for the entire system of fish propagation.

Several years ago it was evident in Massachusetts that the haphazard methods of the past should be abolished and that a definite system of stocking should be adopted, in order to obtain the best financial results. Under intelligent stocking, whereby fish are put into waters suitable for their best development, it may be estimated that the production of the inland waters of Massachusetts may

be increased to at least tenfold over its past output. In order to accomplish such a result, it was necessary to obtain a new perspective, and in this paper the preliminary steps which led toward this goal are described. The application of these facts is general, but all the illustrations, and specific examples are drawn from Massachusetts. The writer is not familiar with the work of other state commissions, particularly the investigations not published in the annual reports. For that reason all criticism, favorable or unfavorable, is directed to conditions in Massachusetts, and applies only to other states when similar conditions exist.

Natural Abundance.—Nearly every state in the Union possesses many beautiful lakes, ponds and streams, capable of producing an abundance of food and game fish, and in most cases, as in Massachusetts, but few of the many thousand acres of waterways are producing anywhere near their maximum or even normal possibilities. Therefore, it is important, both in the interests of sport and as a source of food supply, that these latent assets should be developed for the benefit of the public.

In Colonial days, when a relatively small population was scattered along the sea coast, leaving the inland waters in their primitive, uncontaminated condition, the abundance of salt and fresh water fish was far in excess of the needs of the colonists, thus giving rise to the fallacy which has been handed down zealously to the present generation, that "Nature would always provide an abundance of fish." Even in this era of conservation this mistaken idea is still deeply rooted, especially among the marine fishermen of our shore towns, and it can only be eliminated by the complete exhaustion of the natural supply, or by the education of the general public.

Decline.—With the advance of civilization great changes have taken place in our waterways. Many times the balance of nature has been overthrown and a new equilibrium established. With the increase in population the coastal streams were first invaded, cities were established on the larger rivers, and various manufacturing in-

dustries were scattered along the smaller streams. In order to supply water power numerous dams were constructed, in most instances unprovided with suitable fishways, thus preventing the passage of such fish as the salmon, shad, striped bass, alewife, smelt and white perch up the coastal streams to their spawning grounds. In this way not only the supply of these fish has been depleted, but the commercial sea fisheries have been indirectly affected by destroying a food supply which attracted the larger predaceous fish to the shores. Manufacturing wastes and sewage, particularly in central Massachusetts, have totally ruined many streams, and have seriously depleted the supply of fish in others by rendering the water unfit for fish life. Numerous legislative measures have been enacted in the past, but the decline has steadily continued, since these laws were either inadequate, or, as was more often the case, not enforced. Likewise, overfishing has seriously depleted local supplies, and in Massachusetts has accelerated the general decline which is so marked in the Merrimac, Charles, Taunton and Connecticut Rivers.

Soon after the establishment of the Massachusetts Department of Fisheries and Game, in 1866, salmon and shad hatcheries were located on the principal rivers as long as any native fish remained; but during the last twenty years brook trout have formed the main output of the state hatcheries. These fish, reared in variable quantities, were indiscriminately dumped into ponds or streams at the request of individuals, who filled out brief descriptions of the waters in question. Lack of funds make it impossible to examine these waters, and reliance had to be placed on the judgment of unskilled observers. In many cases this hit-or-miss stocking was successful, in others a failure, resulting in financial loss.

The chief objections to indiscriminate stocking may be enumerated as folows: (1) Stocking private ponds and streams from which the public are excluded. (2) Intentional distribution of fish by the applicant in other waters than called for by the petition. (3) Stocking badly pol-

luted streams in which the young fish cannot exist. (4) Putting fish in brooks which become dry in the summer. (5) Introducing fry or small fingerlings into streams containing large numbers of voracious fish, and conversely introducing coarse fish into trout waters. (6) Stocking where conditions are unfit for the life and spawning of the particular species, or where there is a deficiency of food. (7) Utilizing poor streams to the neglect of more suitable waters. (8) Lack of systematic and consecutive stocking. (9) Financial loss from stocking in unsuitable quantities.

The method of stocking in vogue in Massachusetts until the last few years has been of questionable value, results have been inconsistent, ponds and streams have been stocked with wrong species of fish, and considerable money has been expended without completely satisfactory results. The methods of propagation have not been entirely adequate to offset the increasing causes of decline, such as pollution, dams without fishways, illegal seining, liming and dynamiting. Hand in hand with propagation should go proper restrictive laws, which *must be enforced.*

Stocking.—The stocking of inland waters has three essential parts: (1) The rearing of fish at the hatchery with its expense, labor and numerous attending problems which have caused it to be considered the entire solution of fish propagation. (2) The successful distribution of the young fish, with the difficulties of transportation, and resulting methods for the successful handling of large and small quantities. (3) The selection of the waters into which the fish are to be placed. In this regard our perspective has been at fault, since first of all it is important to obtain a thorough knowledge of the waterways as a ground work upon which to establish an intelligent system of stocking. The need is the same in all states, and the results should approximate those expected in Massachusetts.

The benefits derived from the proper development of the inland waters are: (1) Increased facilities for sport

and recreation. (2) More business from vacationists. (3) A larger food supply. (4) New cottages and pleasure resorts upon our inland waters, developing taxable property.

Biological survey.—The first step toward forming a systematic basis for future stocking is a biological survey of the inland waters. A complete biological survey would include a detailed study of each pond or stream with its intricate correlation of plant and animal life extending not over one, but over several years. With the state commission the extent and thoroughness of such a survey is necessarily limited by expense and practical results. In Massachusetts the following plan of work has been followed in order to obtain the necessary information for practical stocking with the least expenditure of time and money, and for this reason completeness has been sacrificed. Nevertheless, a thorough biological examination of the important waters in any state is of special value when carried on in a systematic way for a series of years, especially when it is connected with experimental work upon fish in typical waters.

Three years ago Massachusetts began a survey of its inland waters in order to obtain the necessary information for systematic stocking. For this work a method of obtaining a knowledge of the ponds and streams at a comparatively slight expense was evolved. The work was divided into four parts, and was carried on during the summer months, when time and funds were available. The first step, a study of the ponds and lakes, was followed by an investigation of the coastal streams up which the alewives, or branch herrings, once ran in large numbers, while the third was the classification and description of the smaller brooks and streams. The fourth, as yet incomplete, comprised a study of the fishing potentialities of the larger rivers, and was intimately connected with that great bugaboo of anglers—pollution.

This preliminary study by no means completes the problem. Succeeding it should come more careful and detailed work, designed to ultimately increase the supply

of food and game fish by: (1) A study of the food, growth, spawning and habits of the different species of fish inhabiting various waters. (2) The determination of the species best adapted to certain classes of water by an experimental study of typical waters. There are, therefore, two parts—first, the preliminary general work, consisting of an extensive biological survey of the waters in regard to their general conditions to form a guide for future stocking, and a classification of these streams and ponds into certain groups, according to the similarity of the natural environment; secondly, an intensive study of various typical waters, representing the groups above mentioned, as regards the effects of the natural conditions upon fish life. In such bodies of water records of temperatures, amount of food (plankton) and general changes which concern the problem of fish life should be followed for a number of years. The work on these typical waters should serve as a basis for interpreting the conditions in other waters of a similar nature.

(1) Ponds.

The Massachusetts law provides only for stocking natural ponds over twenty acres in area, excluding all artificial ones. For this reason the survey was limited to the natural ponds over twenty acres, in all about 800. These ponds were examined in a rapid but comprehensive survey by representatives of the state commission. This work was carried on during three summer months for two years by four biological students. The entire cost was less than two thousand dollars, the greater part of the expense arising from traveling, owing to the inaccessibility of many ponds. Each man examined approximately one hundred ponds in seventy-five days, an average of one and one-third ponds per day. The size and importance of the body of water made considerable difference in the amount of time devoted to the examination, the small and less important receiving a rapid survey. At best the examination was hurried and superficial, but it achieved the practical object of providing an

inventory of the state ponds, and an available working knowledge of the various bodies of water.

The field equipment of the surveyors consisted of a rucksack, a net of silk bolting cloth for towings, hand lens, bottles, vials, formaldehyde, maximum and minimum thermometer, sounding lines and lead, and record blanks. Reports were written at approximately two-week intervals, while the towings and other material were sent to a central laboratory for microscopical examination. As light an equipment as possible was given the field worker, since in many cases he had to traverse the ground between one pond and the next by walking. Numerous difficulties, such as lack of boats, inability to find the ponds, changes in the maps, and lack of transportation facilities retarded the work.

Certain ponds in various parts of the state, from Berkshire to Barnstable Counties, were selected for type study. The other ponds of the state were placed in these representative classes, each pond falling into the group for which its environment was best adapted. The types under observation were large and small ponds, both deep and shallow, in which the conditions, as regards the species, growth and abundance of fish were quite different. From the study of the type ponds, and from classification of the surveyed ponds, practical deduction as to the species and amount of fish for the individual ponds of the state could be made.

In the survey work the following information concerning the physical characteristics of each pond was obtained in order to insure the proper classification for each type:

Name. The name of the pond is a variable and confusing factor. Usually a pond has several names, according to the various maps upon which it is recorded, and often these listed names are unknown in the immediate vicinity where local titles are in vogue. To facilitate the identification of any body of water for public information or for stocking, the primary essential is the recording of all the names by which the pond is known.

Location. The situation of the pond as to the ease or difficulty of access from railroad stations or nearest villages, as well as the hotel and boating facilities, were recorded for use in future shipment of fry or fingerlings, and as a source of information to fishermen.

Area. No actual survey of the area of the ponds was made, the size being measured from maps or taken from old records.

Depth and bottom. Soundings were so made that the contour lines, giving the depths, could be charted on diagrams of the ponds, and from these measurements, the average and maximum depths were ascertained. The sounding lead was equipped to take samples of the bottom soil, but, unfortunately, on hard or mossy bottom no soil could be gathered by this method, and the nature of the bottom could only be estimated in shallow water or from the character of the shores.

Water. The color of the water was listed as either clear, green or brown. The turbidity was expressed in feet, the number representing the distance below the surface at which a white four-inch circular disc would disappear from view. By means of a maximum and minimum thermometer the temperature at the bottom was taken in various parts of the pond to determine the presence of springs. In the deepest part a series of readings were taken at intervals from two and a half to five feet to determine the thermocline (described by Dr. E. A. Birge of Wisconsin), or point where the temperature drops rapidly. Deep ponds have three layers of water—a surface layer, in which the temperature to a depth of fifteen to twenty feet remains approximately the same as at the surface; a middle layer, or thermocline, in which there is a rapid fall, and a bottom layer of uniformly low temperature. The extent and nature of these three layers, which vary in different ponds and at different seasons of the year, are of importance as regards fish life from the standpoint of food and oxygen.

Shores. The shores around the pond were classified as woodland, the kinds of trees being noted, and whether

fields were cultivated or uncultivated, such as pasture, meadow and marsh land. The height and slope of the shores and character of the beaches were likewise noted. Cottages, hotels, gunning stands, ice houses, etc., were recorded as indicating the popularity of the pond as a pleasure resort.

Inlets and Outlets. The inlets and outlets with the volume of water, temperature, amount of sediment and pollution, such as manufacturing waste or sewage, were described. The presence of a dam at the outlet indicated that the pond had either been raised above its original area or that it was wholly artificial. In certain instances it was practically impossible to definitely determine whether a pond thus raised was originally a state pond.

Fish. Information concerning the different species of fish was obtained from fishermen and people living in the immediate vicinity, who were acquainted with the pond. In the rapid survey it was manifestly impossible to obtain this information in any other way, and for this reason the question of the quantity of the fish and the present production of any pond was only determined in a very general way, as the term "good fishing" is but relative, varying with locality.

Fish food. The study of fish food was undertaken in two ways: (1) The examination of the stomach contents of various species, both of the small and the large fish, under various conditions, and at different seasons. (2) The determination of the character and amount of the floating organisms (plankton) in the different ponds by means of a silk bolting cloth net.

(2) Coastal Streams

The second step was a survey of the coastal streams in connection with the alewife or branch herring fishery. Formerly the alewives ran up these streams in great numbers each spring to spawn in the fresh water ponds. In this work the coastal streams and their tributaries were examined by a representative of the state commission. Every dam, obstruction, fishway, cranberry bog,

mill, or possible source of pollution was accurately charted and described. The physical characteristics of the streams, and the animal and plant life were recorded. The method of catching the alewives, the history of the fishery from old records, the possibilities of restocking were studied for the purpose of formulating proper measures for the development of this fishery.

(3) Inland Streams

The third step in the survey of the inland waters comprised a record of the smaller streams. It was manifestly impossible from the standpoint of time and expense for any one man, or even several men, to attempt to personally examine a large number of brooks. The solution of the problem was achieved by enlisting the services of the various state fish and game wardens, each covering a district with which he was thoroughly familiar, especially in regard to the streams. The employment of men, for the most part not trained scientists, necessitated simplifying the examination, but many practical points concerning the various brooks were obtained. Many of these wardens had been stationed for years in their districts, and in the course of their duties had become personally familiar with most of the streams.

Each warden was given typewritten instructions as to the desired information, and the manner in which he could co-operate was explained by a personal interview. The warden, in connection with his regular duties, gradually accumulated the necessary data, and after several months was able to describe with the aid of a map every stream in the district. Naturally more information was available upon some brooks than on others, as certain wardens showed greater aptitude in the work. In addition, many important facts were obtained from local rod and gun clubs.

The information thus obtained was systematized and recorded in the form of a card catalogue (8x6 in. cards), in which the names of the brooks were arranged alphabetically. Each stream had two cards, one a record of

the various fish, with which it had been stocked in the past, the other a typewritten description, comprising the information obtained from the wardens.

Information upon each brook was compiled on the following plan:

(1) The collection of all names, general and local, under which the brook is known, is essential for reference to locate petitions for stocking, and answer requests for information.

(2) The location of the brook by towns or sections of a town is necessary for identification, as two brooks with the same name often may be found in the same town. The brook is then charted properly and named on the U. S. Geological Survey maps, which are cut into small numbered maps of a suitable size for filing with the cards.

(3) The source, whether in spring, swamp, bog, pond or elsewhere is noted; likewise into what body of water the brook flows.

(4) The length and direction of its flow; the width and depth of the stream at certain places along its course; the character of the land through which it flows, *i.e.*, meadow, tilled land, pasture, swamp, hard wood, etc.; the rate of flow, volume and clearness of water, the presence of springs and character of the bed.

(5) The abundance or scarcity of vegetation, with the names of the various water weeds known to the examiner.

(6) The nature and character of any pollution, whether sewage, sawdust or manufacturing wastes, and a description of the source of this material.

(7) It is important to know whether the land bordering the brook is posted and the public denied the right of fishing, in order that no private brook may be stocked by the state.

(8) Information as to whether the stream dries up during the summer is an important consideration in stocking.

(9) The species of fish in the brook, the results from past stocking, if any, and the popularity of the stream with fishermen.

(10) The opinion of the warden as to whether the brook is worth stocking, with what kind and size of fish, and what places afford the most desirable points to liberate the fish.

The method of obtaining information recommends itself for its cheapness, the entire expense consisting of the salary and traveling expenss of the person compiling the information, and for clerical services. Nearly every state employs a force of deputies, who are available for collecting this information, and a record of its brooks can be conveniently and cheaply obtained in a similar manner. Likewise, the same plan may be applied to the ponds, instead of the more complete examination previously described in this paper. In any event, it suggests a convenient plan for compiling practical information upon public waters.

The records, it is true, show frequent errors, and in many particulars are incomplete, owing to lack of detailed information on certain streams, but these gaps can be filled in the future, since each warden is supplied with duplicate records in order that he may correct or add to the information at hand. In this way he will know exactly the information on file at the central office, and can receive shipments of fish or definite orders without any mistakes arising from a confusion of names. It is believed that the compilation of these records will be a great aid to Massachusetts in carrying forward a definite and intelligent policy of stocking. Not only will the state department be in a position to dispense information to numerous fishermen, but it can more readily classify the petitions for stocking.

But the program for the future considers a broader application than a mere bureau of knowledge. It aims to utilize this information so that a plan of systematic stocking may be devised whereby the commission will no longer wait, as is now often the case, until a petition for stocking a stream is received, but will know for several years ahead just what brooks are to receive their stated allotments of fish. With the proper knowledge at hand a

system of stocking will be devised whereby the results may be followed in different brooks, where the right species and number of fish will be placed in suitable waters, and where every dollar of the state's money will yield its maximum value. When such results are accomplished state commissions may feel justified in increasing the output of their hatcheries to meet a larger demand.

(4) Pollution.

The fourth step will be the examination of the rivers. Since these streams are greatly polluted by sewage and trade wastes, this investigation will be confined chiefly to the pollution problem, and an effort will be made to stock with hardy species of fish those streams which have not become veritable sewers. Exactly how this problem will be solved has not yet been determind, but it will be along the line of least resistance, by first eliminating the unnecessary pollution, which can be avoided at a slight expense. By cleaning up the single cases of pollution, and preventing new sources, part of our streams may be saved. Later areas of greater pollution may be considered, but the problem is difficult, and may never be satisfactorily solved.

Summary

This paper has endeavored to show:

(1) The need of a new viewpoint in stocking state waters.

(2) How the defects of former methods may be remedied by a proper selection of the inland waters, a problem long considered of minor importance.

(3) The necessity of a preliminary survey of state waters as a basis for future stocking.

(4) That such a survey may be made in a relatively short time, and at a slight expense.

(5) That the future development of state waters demands a definite program of systematic stocking.

NOTES ON THE REARING OF SALMON

By H. B. Torrey and D. E. Lancefield,
Reed College, Portland, Oregon.

I.

Raw versus Cooked Beef Liver as Food.

Finely ground beef liver has long been highly esteemed by fish culturists as a food for salmon fingerlings, in spite of its cost. The custom has been to feed it raw. That this has been so is due partly to the widespread belief that raw foods more closely approach the natural food of the species in the wild state, and are accordingly more satisfactory; partly because, in the absence of definite tests, no good reason has appeared for assuming the added expense of preparation which cooking would entail. It is a common practice to soften refractory tissues, such as the bones and cartilages of fishes, with superheated steam. But this method of preparation would be quite superfluous for beef liver, unless it could be shown that cooking would actually increase the efficiency of the liver fed.

We have attempted to find a definite answer for this problem. Our experiments are not concluded, so that the results so far obtained must be considered tentative.

The method of investigation consisted in dividing a given lot of Chinook salmon that were just beginning to take solid food through the mouth into two numerically equal groups. These were placed side by side in separate troughs, the flow of water, temperature and all other conditions being as nearly as possible the same with the single exception of food. One group was fed on raw liver, the other on an equal daily weight of cooked liver. The weight of twenty fish was taken at the beginning and at the end of the experiment, the average weight per fish obtained in each case and the average gain per cent. in weight during the elapsed time. Four pairs of groups are tabulated.

Amount and condition of beef liver fed daily	No. of fish	Date of weighing	Average weight of 20 individuals	Gain in weight
1. 10 grams raw	1800	Mar. 1	.465 grams	
		Apr. 2	.525 "	13 per cent.
2. 10 " cooked ...	1800	Mar. 1	.465 "	
		Apr. 2	.590 "	27 " "
3. 20 " raw	2000	Mar. 1	.500 "	
		Apr. 2	.625 "	25 " "
4. 20 " cooked ...	2000	Mar. 1	.500 "	
		Apr. 2	.875 "	75 " "
5. 30 " raw	2000	Mar. 1	.535 "	
		Apr. 2	.555 "	4 " "
6. 30 " cooked ...	2000	Mar. 1	.535 "	
		Apr. 2	.795 "	48.6 " "
7. 40 " raw	345	Apr. 5	1.13 "	
		Apr. 19	1.35 "	
		May 19	1.96 "	73.5 " "
8. 40 " cooked ...	345	Apr. 5	1.13 "	
		Apr. 19	1.48 "	
		May 19	2.36 "	108.85 " "

It will be seen that in each case the fish fed on cooked liver gained weight faster than the others. Excluding from consideration Nos. 5 and 6 on account of the abnormally small gain of the fish fed on raw liver, the fish fed on cooked liver gained in weight from 1.48 (Nos. 7 and 8) times to twice (Nos. 1 and 2) and three times (Nos. 3 and 4) as much as the others in the same time. Including Nos. 5 and 6 the results would be still more strikingly in favor of cooked liver as food.

To find the efficiency of the food per unit of cost, it is necessary to take into account certain losses that took place in the process of grinding and cooking, and in the elimination of tough connective tissue unsuitable for food. In ten weighings, the raw liver lost, in preparation, an average of 33 per cent. of its original weight. Similarly the cooked liver lost 43 per cent. of its original weight. This means that for every 100 grams of raw liver available for food, but 85 grams are available after cooking, showing a loss in weight of 15 per cent. in the cooking.

Expressed in a slightly different way, cooking the liver adds 17½ per cent. to its cost. This increased cost is much more than offset, however, by the gain in results of from 48 to 200 per cent.

II

Factors Other Than Food That Influence the Development of Salmon Alevins.

Seven uncovered glass dishes, each 9 cm. in diameter, were each supplied with 150 ccm. of spring water. On January 3rd Chinook alvins, just hatched, were distributed among them as follows: Dish 1, 3; dish 2, 5; dish 3, 10; dish 4, 15; dish 5, 20; dish 6, 25; dish 7, 30. All lived, without change of water, until January 23rd, when all the fish in dish 7 died.

On January 24, all in dish 6 died, several of them having begun to show clear signs of diminishing vitality by January 16.

On January 24, 3 individuals in dish 5 died, and the others seemed so feeble that the water was changed. By February 15, 19 had died, the rest two days later.

On February 2, 14 of the 15 in dish 4 died, the last dying the next day.

On February 1, the fish in dish 3 were observed to be less lively than at first. On February 15, 8 died; on February 17, the other two.

Of the fishes in dishes 1 and 2, all lived until March 23, when they were killed by a rise in temperature of the water, the dishes having been exposed inadvertently to the sun all day. Up to this time they had been active and healthy. A growth of algae in the dishes led to a change of water in both dishes on February 21. It is probable that they would have lived indefinitely had they not been subjected to the abnormal rise in temperature on March 23.

Notwithstanding their apparent health and nervous activity, the individuals in dishes 1 and 2 were much

behind those of the same age that had remained in the hatchery troughs in running water. While the yolk sacs of the latter had been absorbed by March 1, the yolk sacs of the former were still prominent when they died, three weeks later.

The water in the dishes used was 2.5 cm. deep, with a surface 9 cm. in diameter, and a volume of 150 ccm. Under these conditions 30 fish lived for almost three weeks, in a quantity of water equal to 5 ccm. per fish. With 30 to 50 ccm. per fish, the latter lived much longer; but their rate of growth was materially retarded in correlation with a diminished rate of absorption of the yolk sac—that is, a diminution in food supply.

The volume of water per fish is thus seen to be a factor in development. It is also true that the amount of surface exposed to the air per unit of volume, or the shape of the body of water, exerts a definite influence upon the result. Five fish in an open bottle filled to the neck with 55 ccm. of water with a surface 1 cm. in diameter died over night, January 7-8. In troughs where the water is being renewed several times an hour, we have compared the rate of growth of fishes in water at depths varying from 7 to 14 cm., but have found no significant difference in the rate of their growth.

ON SOME DISEASES OF FISHES

By G. A. MacCallum, M.D.
New York, N. Y.

Through the kindness of the director, Dr. Townsend, and his assistant, Dr. Osburn, of the New York Aquarium, I have had the opportunity of performing several hundred autopsies upon fish of many different kinds which have died in the Aquarium during the last three years, and it is at their request that I outline here the types of disease encountered. A similar privilege has been granted me by the director of the United States Bureau of Fisheries Laboratory at Woods Hole, Mass., during each summer, and it is instructive to compare the conditions found in freshly captured, free-living fish with those occurring in fish which have been for some time in captivity. Probably no statistical studies could be made in this way, because in the ocean diseased fish might not be taken in the proportion in which they actually occur, either because they fall out of the shoal, or because of their sluggishness they are destroyed by other fish. On the other hand, for the same reasons they might be taken in excess by other methods of fishing. On the whole it is rare to find in free swimming fish such extremely advanced diseased conditions as are occasionally encountered in the protected tanks of the Aquarium.

My attention has been directed throughout this work especially to the worm parasites of these fish and reports concerning the structure and systematic relations of many of these with statements as to the damage occasioned by them have already been published. In addition to a brief review of their influence upon fish in confinement, the present paper is intended merely to indicate the general character of the other diseases met with, but not really studied. This may be particularly useful in showing what a great field for research lies there. Of the worm parasites, which include representatives of most of the groups of trematodes, nematodes and cestodes, many have been

found in small numbers inhabiting the intestines and other internal cavities without producing any obvious disability in the fish. In cases in which this infection was more external, however, the worms by their very numbers and by their blood-sucking habits had a much more serious effect. This was particularly striking in the case of the ectoparasites of the trematode group, especially in the several forms of *Microcotyle,* which live on the gills of such families of fish as the *Chaetodontidae* (Butterfly fishes), and Angel fishes, 90 per cent of which in captivity die of *Microcotyle* infestation. The same may be said of many of the Salmonidae which suffer from infestation of *Octocotylidae,* etc. These worms, at any rate in those fish living in confinement, increase in such numbers that the gills are in many instances thickly covered with them —and not only do they, with their surrounding slime, impede the access of water to the gills but they drain away the fish's blood to an extent that generally ends in a fatal anaemia. Another striking example of extreme infestation is found in the intestine of such fish as *Roccus lineatus* (Striped Bass), at times so infected with *Echinorrhynchus proteus,* a nematode which embeds its hooked proboscis in and through the gut wall in such numbers that the whole mucosa is covered thickly with their hanging bodies. Not only is an intense inflammation set up by these embedded hooks, but the function of the mucosa is precluded. Still this seems to be less fatal than the infection of the gills. The occurrence of larval forms of various digenetic trematodes and cestodes encapsulated in the muscles and other tissues of fishes are well known and sometimes productive of disablement of the host, although at times the most extreme infection may exist without obviously hurting the fish.

Of the diseases caused by the unicellular sporozoa of the class Myxosporidae, so well known through the work of Gurley and others, relatively little has been seen in this series of autopsies, and of this disease very many more cases have been seen in those fish taken fresh from the sea.

Evidently the tanks of the Aquarium have escaped infection since it is well known that the most fatal epidemics are from this cause, often leading, in the Great Lakes to the death of countless fish. They commonly infect the muscles and subcutaneous tissues, producing tumor-like swellings which project under the skin and may break down into great ulcerations. Sometimes they show only in the form of small whitish nodules in the internal organs, at others in large nodular masses like white tapioca or sago which fill the abdominal cavity, being attached to the peritoneum and the internal organs. The escape of the parasites from ulcers and from dead and decomposing fish spreads the disease and the most drastic measures are necessary if this is to be prevented. The fish which I have found to suffer most from this disease were perch, flounders, alewives, smelts, hake, pickerel and some of the minnows.

Certain bacterial infections have, however, caused the loss of many fish in the Aquarium in the course of the past winter. In these there appeared peculiar ulcerations of the skin, which in a short time so progressed as to cause the death of the fish. They are sometimes numerous and large and often burrow under the skin or even ulcerate into and through the bones, including those of the head. The ulcer usually shows a dirty gray slough which discharges pus. The neighboring scales are loosened and the skin discolored. Apparently these ulcers begin as abcesses beneath the skin, and after death the liver, spleen and kidneys show scores of small abscesses scattered throughout their substance. Cultures were made by Prof. Zinsser, of Columbia University, who found a bacillus growing best at low temperatures, which, when inoculated in pure culture into normal fish reproduced the disease even to the extensive ulceration of the skin. In both the original lesions and in those experimentally produced the bacillus was demonstrated in smears and in sections. This study is still under way and will be published when completed. As far as I know, this disease affects only the fish in the Aquarium, not those taken freshly from the

sea, and it seems obvious that rigid disinfection of tanks, etc., would easily stamp it out.

Many of the fish in confinement show upon autopsy a great distension of the gall bladder sometimes with generalized jaundice. It is usually found to be due to narrowing of the common bile duct by inflammation of its mucosa, although it is sometimes caused by blocking of the duct by parasites. It is not easy to give an explanation of this. A number of examples of the peculiar affection of the thyroid so much studied by Gaylord, Marine and Lenhart came to my attention. As is well known, it is even yet a matter of dispute as to whether this enlargement of the gland which may affect the isolated fragments of thyroid tissue scattered so widely in the tissues of the fish is to be regarded as a malignant tumor or not. It is at least destructive of the lives of many fish in hatcheries of trout, but Marine thinks it merely a modification of the gland caused by unsuitable food and over crowding, and especially by lack of iodine-containing food. Gaylord thinks it cancerous.

A few more definite tumor growths have been encountered, one which produced a rounded protuberance on each side of the dorsal fin of a *Neomaenis griseus* (Gray Snapper). These proved on section to be a hard fibroma composed of very dense fibrous tissue with relatively few cells. Two fish, a red hind and a pickerel, died after an affection of about three months during which the soft tissues of the lower jaw and part of the tongue were wholly destroyed leaving the bones completely bare as far as the angle of the mouth. This was at first thought to be an epitheliomatous growth but sections of the margins of the tissue showed no tumor and the nature of the process is obscure. A large snook (*Centropomus undecimalis*) was observed for a long time in the Aquarium with a large tumor on the tip of its lower jaw, which may possibly have been of the nature of the thyroid enlargements. Unfortunately it was not studied at autopsy. Another, a black grouper (*Mycteroperca bonaci*) showed at autopsy a firm nodular mass constricting the rectum which was

greatly dilated above the structure. There were many adhesions and inflammatory products in the neighborhood. Again through an accident the tissue was lost so that the exact nature cannot be stated. In large *Cynoscion regalis* (Squeteague) there was found a tumor of the testis about 15 mm. x 15 mm. x 10 mm. This was sectioned, but not yet studied.

Fragmentary as these notes are, representing only incidental observations of conditions not carefully studied except in the case of the worm parasites, they are given to indicate what an extensive field for study presents itself in the pathological conditions found in the fishes at the Aquarium.

STRAY NOTES FROM PORTO RICO

By J. T. Nichols,
American Museum of Natural History, New York City.

The writer has had the good fortune to spend the better part of the past July studying the fishes of Porto Rico in the interest of a biological survey of that island which is being forwarded by the New York Academy of Sciences and the Insular Government. The material collected has not yet been studied, and indeed a discussion of the detailed scientific results obtained would be out of place here. Certain observations, however, he has had in mind to talk over with members of the American Fisheries Society, and these are herewith presented.

The Silk Snapper, *Neomaenis vivanus,* is a deep-water, yellow-eyed representative of the more familiar Red Snapper. Evermann and Marsh in Bulletin XX of the U. S. Fish Commission for 1900, speak of it as one of the important food fishes of the island, but say that it was not common in Porto Rican markets during their visit, though Mr. Oscar Riddle found it quite common in the San Juan market at certain times. On July 13 of this year it was exposed plentifully for sale in the San Juan market. As Evermann and Marsh were on the ground in winter, the difference may be a seasonal one. The data at hand are as yet quite insufficient to determine this. A herring, *Sardinella sardina,* not listed in the U. S. Fisheries Bulletin referred to, but found abundant this summer at San Juan, also may be of seasonal occurrence.

The Barracunda or "Picunda" is one of the more favored food-fishes in Porto Rico. The waters of San Juan harbor are unfortunately badly polluted, and the fish from near there consequently looked on with suspicion, this species less so, because it is thought to feed exclusively on active live food. In Cuba the Picuda is looked on with much disfavor. Large individuals especially are consid-

ered sometimes to be poisonous, but in Porto Rico nothing detrimental was heard about the species.

The fresh-water fish fauna of Porto Rico is very scant even considering the limited fresh waters of the island, and it may be advantageous to introduce game or food species as the demand for fish exceeds the supply and much salt-cod is marketed. At Guanica a large shallow lake, with edges plentifully grown with water plant and containing Top Minnows, *Poecilia,* in abundance, has the disadvantage that its waters at times doubtless reach a high temperature. Near Guayama sizable lakes have recently been made for irrigation purposes by damming back the stream. One of these lakes visited seemed notably barren of plant and animal life and probably some food would have to be introduced before larger fishes would thrive.

It is interesting that at one point on the island, Isabella, the common aquarium goldfish is found. From there some specimens have been brought to a small pond on the Governor's place in the hills above Guayama where they are doing well and breeding. The goldfish is primarily a cold-water fish and its introduction in the tropics is interesting.

THE USE OF SALT IN SEPARATING UNFERTILIZED FROM EYED EGGS

By G. H. THOMSON,
Estes Park, Colo.

The use of salt for the separation of dead eggs has been tried successfully in the Government salmon hatcheries on the Pacific coast, but I have never heard of this method being applied to the eggs of the Brook Trout. Any method that will avoid the tedious picking out of individual eggs, which is the usual way of getting rid of them, is desirable to save labor and time. The results of my experiments with the eggs of the trout may therefore be of interest to fish culturists.

During the last winter the hatchery was filled with brook trout eggs, and when these reached the stage when the embryos began to show and the eggs could be handled without danger, I began these experiments. When the dead eggs have reached a certain stage and with the salt solution at the proper density, the separation becomes a very simple matter. As the living eggs settle to the bottom while the white eggs remain at the top, the latter can be removed in a dipnet by the hundreds instead of one at a time. The live eggs may then be returned to their trays without injury.

The white eggs cannot be separated by this method when they begin to turn, for then they have nearly the same specific gravity as the live eggs, but if they are left for three or four days, according to the temperature of the water, they will float readily.

With the aid of a hydrometer I found 36 degrees to be about the right density for the salt solution and then by making a preliminary test of a few eggs the water could quickly be brought to the proper density for use. If the salt solution is too dense all the eggs will float, but if the density is too low they will all settle to the bottom.

For the work of separating the eggs I use a wooden bucket in which is fitted a wire screen on which the live eggs can be quickly removed after the dead ones have been skimmed off. When I have everything ready I remove the trays from the hatching trough and let the water drain off so as not to dilute the salt solution. Then with the aid of a feather I remove the eggs from the tray into the solution. If the density is right, the live eggs settle at once to the bottom while the dead ones remain at the top and are quickly removed. The live eggs are then returned to the tray. Three or four days before I intend to use the salt I wash the eggs by shaking the trays, in order to turn all the dead ones white that I possibly can. Even then there will be some that will not turn at this time, so that after using the salt solution it may appear that one is not getting results, but careful observation will show that all have been removed that are near the danger line of fungus.

The time consumed in handling the eggs is not determined by the number of dead ones removed, but by the time required for handling the trays, putting the eggs into the solution and replacing the good ones in the trays. I found that nine trays of 5,000 eggs each could be handled in 36 minutes. Where the condition of the fertilization of the eggs required the removal of 66 2/3% before the hatching was over, I proved that one man can do more work in one day than six can accomplish by picking the eggs out one at a time. And the eggs are left in better condition, for all the sediment is removed, even that which the shaking and washing will not remove, and the eggs are left perfectly clean and clear.

If a mistake is made in handling the eggs in the salt solution, they cannot be handled again the same day, for they will not separate again until they have been for some hours in fresh water.

Care must be taken to have the salt solution the same temperature as the water of the hatchery, to avoid injury to the eggs.

It may be asked if there are not many live eggs removed with the dead ones. Only when I handled them near the hatching period when the eggs could not be allowed to remain in the solution for the time required for proper separation. In this case I took a sample and found two ounces of live eggs in a total of twenty-five ounces of eggs removed. Even then I saved a vast amount of time and labor by using the salt solution.

I have experimented a little with the green eggs, but without satisfactory results.

All the eggs that I had in the hatchery last winter were handled by myself, single-handed, in the eyed stage, and this summer I have handled over 800,000 of the rainbow and black-spotted trout with equally good results, so I no longer dread the work of picking out the white eggs at the eyeing stage. The salt solution properly used will save a great deal of labor and expense in the operation of a hatchery. There is no reason why we should not progress in practical fish culture as well as in other lines of industry.